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A new series of ferromagnetic substances: the ferrites of the rare earths

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Summary. Preparation of a new series of ferromagnetic compounds of the ferrites type, corresponding to the general formula Fe_2O_3, M_2O_3, in which M represents one of the elements of the rare earths; study of their stability and the variation of their magnetisation as a function of the temperature.

The general method of coprecipitation made it possible for one of us(1) to prepare in the pure state a series of compounds of the type Fe_2O_3 MO (ferrites) and to demonstrate their magnetic properties. We adopted this method (frequently made use of since then) to attempt to obtain a new series of ferromagnetic substances of the type Fe_2O_3, M_2O_3, where M stands for one of the rare earths La Pr Nd Sm Er and Y.

The reaction $Fe_2O_3 + M_2O_3 = Fe_2O_3.M_2O_3$ is brought about by reheating of the coprecipitated mixture of the corresponding oxides. They are stable at high temperature (1000°C). $Fe_2O_3.Nd_2O_3$, however is decomposed by heating for several hours at 1000°, into Fe_2O_3 and Nd_2O_3 (identifiable by examination in X-rays and the Curie point of Fe_2O_3); here an analogy may be seen with certain unstable ferrites which we had already investigated(2).

The Curie Points occur for these ferrites of rare earths, at the following temperatures:

Fe_2O_3 (La_2O_3 - 465° ; Pr_2O_3 - 425 ; Nd_2O_3 - 300)

Fe_2O_3 (Sm_2O_3 - 300° ; Er_2O_3 - 255 ; Y_2O_3 - 275)

They are classified as follows, in descending order of magnetisation: Nd; Er; Y; Sm; Pr; La; magnetisation determined after heating above the Curie point followed by cooling in a field of 2000 gauss. For comparison we quote that nickel ferrites has, under the same experimental conditions, a magnetisation four times as great as $Fe_2O_3.Nd_2O_3$. We here reproduce the curves of thermomagnetic analysis, obtained by means of our recording apparatus.

On the other hand, ferrites of lanthanum and praseodimium show to a marked degree, the phenomenon of thermoremanent magnetism, discovered by one of us(3) in sesquioxide of rhombohedral ferric oxfde and the ferrites Fe_2O_3. MO. This magnetisation reaches a value 20 times greater than the initial magnetisation of Fe_2O_3, La_2O_3 and 10 times greater than that of Fe_2O_3 Pr_2O_3.

Except in the case of neodymium ferrites, we observed that the proportion of ferromagnetic ferrites formed (in general very small at a temperature of 700°, even after prolonged heating) remained

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less than 50% after prolonged heating at 900°. In this way we obtained, for example, with Fe_2O_3. Er_2O_3 after heating for 6 hours at 1000°, a product of which the magnetisation was three times as great as after heating for the same length of time at 920°. Such a high temperature was not necessary for the formation of the ferrites Fe_2O_3.MO (completely formed after heating for four hours at 900°).

On the other hand, for Fe_2O_3.Nd_2O_3 (unstable ferrites), the maximum magnetisation (which can be attributed to about 80% of the product formed, according to the X-ray spectrograms) was obtained by heating for three hours at 775°.

All these results demonstrate the existence of a new series of ferromagnetic substances, of which the crystalline structures are being investigated at present.

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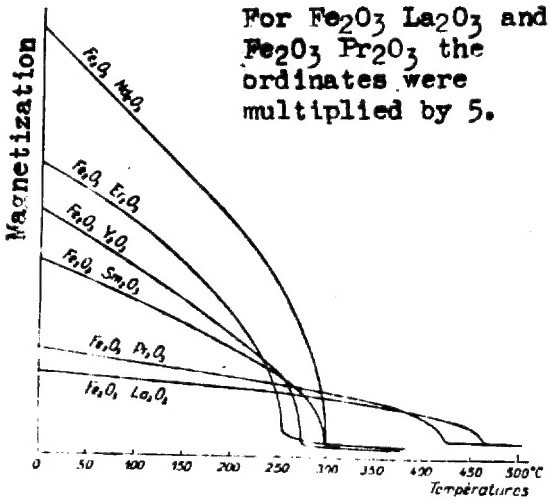

For Fe_2O_3 La_2O_3 and Fe_2O_3 Pr_2O_3 the ordinates were multiplied by 5.